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History, research and practice of Forensic Anthropology in Thailand

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Abstract

Forensic Anthropology is an increasingly developing discipline born about a century ago in the United States with the objective to contribute the knowledge of bone biology and physical anthropology to the emerging needs of the court of law. The development of research in biological and forensic anthropology has made rapid progress worldwide in the past few years, however, in most countries-with the exception of the United States- forensic anthropology work is still considered within the duties of the forensic pathologist. This paper attempts to summarise the history and development of forensic anthropology in Thailand by providing information on past and current research and practice that can help forensic practitioners to apply existing methods in forensic cases and mass disasters. It is hoped that the lessons learned from the tsunami catastrophe and the emerging need for positive identification in medicolegal settings will lead to rapid advances in education, training and professional engagement of anthropologists from the forensic departments and the law enforcement agencies in Thailand.

Key-words: Forensic Anthropology, Thailand, biological profiling, positive identification

Introduction

Forensic anthropology traditionally deals with the examination of human remains for legal purposes. It derives from the fields of anatomy, physical anthropology and forensic medicine. The discipline became established in the 1940s, when physical anthropologists were first engaged by law enforcement agencies to assist with the identification of unknown skeletal remains. Physical anthropologists were also recruited by the American military to identify United States (US) soldiers during World War II and the Korean War. Currently, anthropologists are tasked with helping authorities with the identification of human remains in forensic casework, in mass disasters and mass graves. For example, Australian forensic anthropologists assisted the Disaster victim identification (DVI) team to establish the fragmentary skeletal remains in the bushfires disaster in Victoria state, Australia which caused 173 casualties [1]. Yet the degree of acknowledgement of their expertise varies significantly between continents and amongst different countries. Naturally, countries that have suffered mass catastrophes such as the World Trade Center bombing (September 11, 2001, US) or national or civil wars (e.g. Argentina, Venezuela, Bosnia, Kosovo, Cyprus) have acknowledged the value of forensic anthropologists as a vital part of interdisciplinary teams in the examination of unknown, heavily decomposed or skeletonised human remains much earlier compared to others. The 2004 tsunami catastrophe in Thailand clearly indicated the lack of such expertise in a country in desperate need of services to identify a large number of victims simultaneously.

Roles of forensic anthropologists in death investigation

To assist the death investigation process, forensic anthropologists can help in the identification of skeletal remains by deducing biological characteristics such as sex, age, stature, and ancestry from the skeleton. Time of death, possible trauma, or pathology that led to death can often be assessed by skeletal remains [2-5]. To achieve this the forensic practitioner has to examine the remains, apply appropriate methods and interpret the results. Standard guidelines for observation, measurement and recording data from the skeleton are available for both the US [6] and the United Kingdom (UK) [7]. As for the methods of biological profiling, most scholars agree that these methods tend to be population specific, which creates a need for developing standards representative for each part of the planet. The Scientific Working Group for Forensic Anthropology (SWGANTH), founded in 2008 by the Federal Bureau of Investigation (FBI) and the Department of Defense Central Identification Laboratory (CIL) in the US, provides a set of best practice guidelines for the forensic anthropology community. A similar document has been adopted by the British Association for Forensic Anthropology (BAFA) in the UK.

The development of research in biological and forensic anthropology has made rapid progress in the US, South America, Europe, Africa and Asia in the past few years [8]. In most countries, however, the practice of forensic anthropology is limited and mostly undertaken by forensic pathologists. The development of the discipline is different in every country, depending on history, status of education, legislation, and forensic practice, which makes the application of generic guidelines a complicated task from the practitioner. It is therefore essential to acquire knowledge of history, current research, and practice in each country in order to apply anthropological methods in legal settings.

In Thailand, forensic anthropology gained particular interest after the 2004 tsunami disaster. This catastrophe forced the entire forensic community to realise that victim identification needs better management strategies and cooperation amongst forensic practitioners to respond to incidents of such scale. Kahana and Hiss [9] stressed that the DVI team should have included forensic anthropologists to assist the identification. This paper is an attempt to summarise the history and development of forensic anthropology in Thailand by providing information on past and current research that can help forensic practitioners to apply existing methods in medicolegal settings and mass disasters.

Forensic anthropological research in Thailand

Early studies

The first study in physical anthropology by a Thai anatomist was published internationally in 1930 by Mr. Sankas. He studied cranial capacity and its relation to each cranial module on the collection of the US National Museum [10]. The pioneer researcher who first worked on a Thai population sample was Dr. Sood Sangvichien at the Anatomy Department of the Faculty of Medicine in Siriraj Hospital. His work focused on developing a sex estimation method from the morphology of the preauricular sulcus [11]. Unfortunately, most of his work was only published domestically or remained unpublished, which resulted in a lack of international acknowledgement of his effort in the field [12]. His interest in the archaeological Thai population became known from his work on skeletal remains during the Thai-Danish prehistoric expedition in Kanchanaburi province [13].

Dr. Sangvichien's son shared his father's interest in physical anthropology. After obtaining his Medical Degree from Siriraj hospital, Dr. Sanjai Sangvichien engaged in physical anthropology research in the Thai population. His first work focused on the estimation of stature in Thai and Chinese populations, using the length of the lower long bones from the donated bodies in the anatomy department [14,15]. His colleagues in the anatomy department expanded the 1950 study by Dr. Sood Sangvichien and confirmed the relationship between the presence of the auricular sulcus and parturition scars in women [16].

The Chiang Mai osteological collection

Recently the number of research articles in forensic anthropology has increased in both domestic and international journals, based on a skeletal collection derived from the modern Northern Thai population of Chiang Mai. The Chiang Mai skeletal collection consists of individuals who died at Chiang Mai University hospital between 1993 and 1996 and donated their bodies for educational purposes to the Forensic Osteology Research Centre in the Faculty of Medicine of Chiang Mai University. The donors were residents of Chiang Mai and neighbouring villages, and belonged to middle and lower socioeconomic classes. The recorded occupations included farmers, public servants, teachers, and retired individuals, among others.

The skeletal preparation as desctibed by King [17] and confirmed by the current curators of the collection was done as follows. Firs, the bodies were dismembered, defleshed, wrapped in plastic mesh bags, and buried in sand to allow decomposition. Second, after about 6 months the skeletal remains were recovered and kept in hydorgen peroxide for 3 days and then left to air dry. Finally, each bone was cleaned and stored in a plastic box. Carpals, metacarpals, tarsals, metatarsals and phalanges were put separately in plastic bags to avoid confusion. The Chiang Mai skeletal collection currently consists of a total of 472 individuals, 289 males and 183 females, with ages ranging from 15 to 97 years, and it has already been used extensively for research. The Forensic Osteology Research Centre in the Faculty of Medicine of Chiang Mai University launched a doctoral program in forensic osteology in 2013, which further promotes forensic osteology research.

Sex estimation

Sex constitutes the primary biological feature of the biological profile, and therefore has correctly gained priority among anthropological studies in Thailand. King [17] studied for his doctoral dissertation 104 modern Thai skeletons from Chiang Mai and developed multiple univariate and multivariate sex estimation equations for cranial and postcranial elements. He demonstrated that the humerus and femur are good indicators for sex assessment in Thais reporting up to 97% and 94% classification accuracy, respectively. Data from King's thesis was then used for comparative studies [18,19]. As expected, the Thai sample yielded low classification accuracy when discriminant functions based on femoral data from 4 different populations (American Blacks, American Whites, African Whites and Chinese) were tested [19].

Osteometric studies for sex estimation were conducted on various other skeletal elements such as the sternum [20], vertebral column [21], radius [22], calcaneus [23], mastoid process [24], patella [25], metacarpals [26], ilium [27], proximal hand phalanges [28], and talus [29]. Each study provides discriminant functions for the estimation of sex based on the metric characteristics of each bone. Table 1 lists the published studies, the reported accuracy and the best single variables. The lowest classification accuracy (74%) was noted for the sternum [20] followed by the mastoid process [24]. The poor performance of these bones limits their value as reliable sex indicators and therefore they are not recommended for use in forensic settings. For methods with acceptable classification accuracy (e.g. over 85%) one would need to have data on posterior probabilities in order to evaluate their reliability for a given case. This is particularly important when sex allocation is based on a single element. The use of all available methods is highly recommended for a more reliable and unbiased sex allocation.

Table 1 here

Age estimation

Studies on age estimation on modern Thai populations are somewhat limited. Schmitt [30] raised the issue of the reliability and validity of western age estimation methods when applied to Asian populations, due to the variation in the aging patterns between the populations. He applied two well-known age assessment methods [31,32] to the modern Thai skeletal collection from Chiang Mai University, using pairs of 66 os coxae. He concluded that these methods are not accurate for estimating age for the modern Thai population and one should be very skeptical in applying them on other Asian population without previous validation studies.

Singsuwan et al. [33] scored five characteristics of the auricular surface in 210 modern Thai skeletons and calculated the composite scores for estimating the age of the individuals. They found that there were no statistical differences between the left and right side, nor between females and males. The age estimation equation was tested on 60 Thai skeletal specimens resulting in 56.4 % accuracy for the left side (with 11 years standard error) and 67.8% % accuracy for the right side (with 10.6 years standard error). The application of this method is not recommended for forensic settings and more research is needed to improve accuracy on age estimation.

Tipmala et al. [34] developed a multinomial logistic regression model to explore the relationship between age and morphology of the pubic symphysial surface to modify Suchey-Brooks' method, using 236 modern Thai innominate bones. The accuracy rate of the modified method was 86.4% for the left and 85.2% for the right pubic bone. This study, however, did not account for sex since the number of individuals in the younger age group was insufficient. The study depicted differences between left and right pubic symphyses' morphology and the author suggested that age phases should be based on separate sets of data for left and right side. This is in agreement with a previous study by Schmitt [30].

In addition to the validation studies on age estimation techniques from the pelvis, cranial suture methods have also been studied by Tiengpitak [35], Kij-ngarm [36], Jangjetriew et al. [37], and Natnicha et al. [38]. Tiengpitak [35] examined 110

Chinese and Thai crania and proposed that the endocranial sagittal suture closure starts between the ages of 23 to 37 years and completes between 31 to 71 years in both sexes. In 1974, Kij-ngarm studied 173 Thai crania and revealed that ectocranial sagittal suture closure startes between the ages of 30 to 40 years and completes between 50 to 60 years in both sexes [36]. Jangjetriew et al. [37] studied 166 skulls from an autopsy room (136 males, 30 females) by scoring ectocranial and endocranial sutures and calculating a composite score. They found that the composite score of endocranial sutures is correlated with age and can be applied to both sexes for age estimation. The accuracy of those methods, however, is affected by the variation of cranial suture closing and should be applied with caution.

Natnicha et al. [38] scored the ectocranial sutures of 100 skulls using a photographic technique and 2D software (ImageJ) and proposed an age predictive model based on stepwise linear regression. They suggested that future research should add younger samples to increase the accuracy of the model.

Traithepchanapai [39] conducted a pilot study for age estimation based on the metamorphosis of the 72 clavicles in a modern Thai population and discovered that the youngest age at which bone overgrowth at the articular surface margin can be noticed in this study is 39 years and that this characteristic is not influenced by sex. Further studies are essential to establish the relationship between these degenerative characteristics and age in Thais. Table 2 shows all existing age estimation methods, the reported accuracy, and a summary of the important observations.

Table 2 here

Stature estimation

Mahakkanukrauh et al. [40] produced stature estimation formulae based on the length of long bones from the Chiang Mai skeletal collection. They collected the metric data of upper and lower limb bones from 200 skeletons and created an equation for each bone. They concluded that the femur gives the most accurate estimate for stature. The validity of the produced formulae though has never been tested on samples from different areas of Thailand. Additionally, Pureepatpong et al. [15] studied 275 skeletons of known height confirming that the femur is the best bone for predicting stature.

In addition to the skeletal collection from Northern Thailand province another modern collection from the Northeast area is available for study. Anthropologists from the US used 800 documented skeletons from the Anatomy Department at Khonkaen University Medical School to establish stature estimation equations from the upper and lower limb bones [41]. Table 3 shows all existing stature estimation methods, equations, and standard error (SE).

Table 3 here

Secular changes

The studies of secular trends in Thailand revealed an earlier onset of puberty in females [42]. The authors studied a sample of 300 school girls in Bangkok and concluded that the onset age of early menstruation and breast development has decreased over the years. They considered the sample size in this study small and suggested that further research into this subject is needed. Since the skeletal age of maturation is related to sexual maturation, the results of this study might also indicate the acceleration of skeletal age maturation in the modern Thai population [43].

The secular trend towards increasing height in the Thai population was also observed by the studies of Jordan et al. [44] and Seubsman and Sleigh [45]. Jordan and colleagues [44] found that the average height, from 86,105 samples, had risen by 1 centimetre. Moreover, they observed the differences between the heights of the urban and rural populations. The increasing rate in the urban population was statistically significantly greater than in the rural population, and the authors proposed that socioeconomic status might have played a role in this. Seubsman and Sleigh [45] studied 33,000 young males and found an increase in height over the last three decades. The authors suggested that improvements in child nutrition, decline of child infection rates, and development of health care may be contributing factors to the changes in stature in the modern Thai population. These results, however, were not confirmed for females. These studies reinforce the notion that population-specific methods created from modern Thai skeletal collections are needed for biological profiling in forensic casework.

Forensic anthropology practices in Thailand

Thailand applies the 'police system' to investigate unnatural death. According to Thai law, the Royal Thai Police Force is in charge of victim identification and they have to establish the manner of death [46]. They obtain the autopsy report, details of injuries, and cause of death from forensic pathologists [47] working at one of the 36 forensic medicine departments in Thailand, as there are no forensic anthropologists currently employed in Thailand. Figure 1 illustrates an unidentified body recovered from the river of Bangkok and sent to the Department of Forensic Medicine of Chulalongkorn University for further examination. This is a case that would require calling upon a forensic anthropologist to assist in positive identification. Instead, the case was exclusively handled by forensic pathologists.

Figure 1. here

When it comes to forensic DNA analysis there are 7 laboratories in Thailand, 6 of which are located in Bangkok. These laboratories are located in Chulalongkorn hospital, Ramathibodi hospital, Siriraj hospital, Central Institute of Forensic Science, Royal Thai Police Office of Forensic Science, and the General Police Hospital. All of these laboratories work on forensic samples collected from crime scenes as well as on questionable paternity cases. The number of staff members employed in these laboratories varies from 2 to 18 and they hold degrees in biomedical sciences, with experience in working in forensic DNA analysis varying from 6 months to 26 years. In 2006, 11,100 DNA samples were processed in total from the 6 labs in Bangkok. A self-evaluation study of the 6 laboratories according to the standard requirements for forensic DNA laboratories based on the American Society of Crime Laboratory Directors/Laboratory Accreditation Board (ASCLD/LAB) and the FBI DNA Advisory Board resulted in 30-99% of compliance. Three of the six labs in Thailand were very close to fulfilling all requirements of ISO 17025:2005. In the beginning of 2007, the Bureau of Laboratory Quality Standards, Ministry of Public Health of Thailand launched an accreditation program based on ISO/IEC 17025:2005 for forensic science laboratories to help Thai forensic laboratories meet the quality and international standards. To date the Central Institute of Forensic Science is the only accredited DNA lab since 2011 [48].

Missing person identification centres in Thailand

The first identification center in Thailand, known as the Central Identification Laboratory, Thailand (CILTHAI) was established in 1973 at Camp Samae San by the US Army. CILTHAI was a relocated US mortuary tasked to search for, recover and identify missing US solders at the Vietnam War. In 1976 CILTHAI's mission was classified as military rather than humanitarian, thus the lab was inactivated, relocated from Thailand to Hawaii and renamed as the US Army Central Identification Laboratory, Hawaii (USA CILHI).

Currently there are two centres that serve for identifying missing persons in Thailand. The first centre is the Missing Person Management Centre (MPMC) of the Institute of Forensic Medicine (IFM), which is commanded by the Royal Thai Police Force. Another centre is the Missing Person Identification Centre (MPIC) in the Central Institute of Forensic Science Thailand (CIFS), which is commanded by the Ministry of Justice. Both assist Thai citizens to identify their missing relatives. The first has operated since 1972 and handles approximately 60 cases of skeletonised remains per year; the latter has operated since 2002 counting about 10 cases of skeletonised remains per year. Both centres apply DNA analysis for positive identification while, anthropological methods in MPIC are applied by forensic scientists were trained by The Argentine Forensic Anthropology Team (EAAF). In addition training was provided to MPIC members at the CIL in Hawaii on several occasions over the past approximately 8 to 10 years. Forensic anthropology, therefore, has a potential role in both centres, and an argument can be made that development of population-specific methods for age, sex, and stature estimation in skeletal remains is essential to the legal procedures in this country.

Suggested new research

Osteometric sex estimation methods developed for modern Thais cover the vast majority of the human skeleton. Craniometric studies are limited to the thesis of King [17], the main focus of which was the comparison between Thai and Hong Kong populations. Up to date methodologies on craniometric sex estimation would allow for a greater application of the method in emerging forensic cases. Additionally Bruzek's method [49] for sex estimation from the pelvis should be tested in Thais. Lastly, morphological methods such as the Phenice [50] and the updated Walker [51] sex estimation methods on pelvic and cranial traits, respectively, should also be tested on the Thai population.

The studies of Schmitt [30] and Singsuwan et al. [33] already show that there is a lack of domestic standards on age estimation for the Thai population, which is an important aspect of biological profiling in forensic investigations of skeletal remains. Both studies agree that the standard age estimation methods, which are based on western populations, did not give accurate results when applied to Thais. Age estimation techniques from other parts of the skeleton should also be validated before adapting these methods to forensic practice [52]. For example methods on frontonasal suture [53], clavicle [54], first ribs [55], chest plate [56], sacrum [57], vertebrae [58], acetabulum [59] should be tested. To validate the existing age estimation methods on different populations, it is recommended that the distribution of age at death, and the mean age of the tested sample should be the same as the original sample [60]. Research regarding to age estimation from dentition based on Thais are currently developed. Lamendin [61] and the latest revised method of Prince and Ubelaker [62] would be a useful alternative age estimation method if proven to be successful in the Thai population. Additionally, histological age estimation methods could also be developed for the Thais in cases that morphology proves inconclusive. It is worth mentioning that the Thai DVI dental team examined 2070 victims of the tsunami catastrophe and managed to release only 111 victims based on dental records [63]. This is definitely an area that needs more attention.

Research on stature estimation methods yielded standards for Thais that seem to be appropriate for the emerging forensic cases. Validation studies on different areas of Thailand are necessary to confirm the suitability of the methods in the entire country. Additionally, smaller bones could be used for developing new stature equations with application to incomplete, fragmentary, and/or scattered remains.

The creation of the Chiang Mai modern skeletal collection is a positive step towards the development of biological standards for the Thai population. Another possible source of material can be the autopsy room. There are several forensic medicine departments in Thailand and collaboration with each other would increase the number of skeletal samples, since some parts of the skeleton are usually removed by normal autopsy procedure, for example, calvarium, hyoid bone, clavicle, sternum, and ribs. Furthermore, most of the deceased in the autopsy room can be identified by sex, age, stature, and ancestry more accurately by their official documents. Yet, there are some limitations when forensic researchers use skeletal samples from this source. First, the appearance of dry bone might be different from wet bone, which is obtained from the autopsy room. Second, the researcher might not obtain some parts of the bone that are not usually removed in a normal autopsy procedure. Finally, the researcher has to get informed consent from the deceased's relatives in every case. The latter concern might also arise for deceased who have no relatives.

Concluding remarks

There are several limitations in the application of forensic anthropology in medicolegal death investigations in Thailand. The knowledge of forensic anthropology is still limited, since the only doctoral degree in forensic osteology started very recently, in 2013. Most of the practitioners work in anatomy departments and they rarely have a chance to assist the police in investigations of skeletal remains since the police often ignore their existence and expertise. The police normally assign unidentified remains to a forensic pathologist for postmortem examination. Forensic pathologists in Thailand might not have sufficient knowledge on how to properly examine skeletal remains, as the forensic medicine training program is limited with regards to forensic anthropology. Furthermore, the specific population data in Thailand for establishing biological profiles is still insufficient. While metric methods of sex estimation have been thoroughly tested, stature and secular changes are currently the focus of several researchers. Many morphological and histological methods are yet to be tested and experts need to get adequate training to start applying them to forensic cases. The Tsunami disaster highlighted the lack of dental records in Thais compared to other countries that suffered losses, which points to the need for future research. Despite the efforts to develop forensic anthropology research in Thailand, the country still is far from providing adequate training and professional opportunities for forensic anthropologists. Hopefully this work will contribute to giving forensic anthropology in Thailand the attention that it deserves.

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Table 1: Sex estimation methods based on Thai populations.

Author	Bone	Accuracy	Recommendation
İşcan et al. 1998	humerus	97.0%	Left epicondylar breadth
King et al. 1998	femur	94.2%	Left max. head diameter and bicondylar breadth
Mahakkanukrauh, 2001	sternum	74.2%	Length of the sternal body
Sinthubua and Mahakkanukrauh, 2001	vertebral column	70-86.5%	Horizontal and anterio-posterior diameter of vertebı bodies
Suwanlikhid and Mahakkanukrauh, 2004	radius	89.4%	Left max. diameter of the head and circumference oı midshaft
Wanpradab et al. 2011	calcaneus	90.5-91.0%	Max. length, body height, dorsal articular facet widt and length
Sujarittham et al. 2011	mastoid process	78.0%	Mastoid width and height
Phoophalee et al. 2012	patella	85.3%	Left max. width of lateral articular facet
Khanpetch et al. 2012	metacarpals	88.3%	Rt. 5th metacarpal and Lt. 1st metacarpal
Mahakkanukrauh et al. 2012	Ilium	93.4-.94.4%	Preauricular streak or sulcus is not present in male Ilium
Mahakkanukrauh et al. 2013	proximal hand phalanges	87.6-92.3%	Left 1st proximal phalanx
Mahakkanukrauh et al. 2014	talus	91.3-91.4%	Trochlear length and breadth

Table 2: The available age determination methods based on Thai populations.

Author	Bone	Accuracy	Observations
Tiengpitak 1964	Cranial suture	-	Endocranial sagittal suture closure started between age 23 - 37 years and completed between 31 - 71 years
Kij-ngarm 1974	Cranial suture	-	Ectocranial sagittal suture closure started between age 30 - 40 years and completed between 50 - 60 years
Jangjetriew et al. 2007	Cranial suture	-	All open sutures were found in age less than 15 years. In the age more than 55 years, the endocranial coronal suture is closed
Singsuwan et al. 2012	Auricular surface	56.4% 67.8%	For the left side, not recommended in forensic setting For the right side, not recommended in forensic setting
Tipmala 2012	Pubic symphyses	86.4%	For the left side
Natnicha et al. 2014	Cranial suture	86.2%	For the right side age = 76.872 – (19.609 x the number of pixels in coronal suture) + (3.710 x the number of pixels in lambdoid suture) SE 13.9 years
Traithepchanapai 2014	Sternal end of the clavicle	-	the youngest age which bone overgrowth at the articular surface margin can be observed is 39 years

Table 3. The available stature estimation methods based on Thai populations.

Author	Bone	Equation and standard error
Mahakkanukrauh et al. 2011	Femur	Male stature = 2.722 x Fem (max) + 45.534 SE 5.06 Female stature = 2.778 x Fem (max) + 40.602 SE 5.21
Pureepatpong et al. 2012	Femur	Male stature = 2.3866 x Fem (max) + 60.334 SE 3.49894 Female stature = 2.4121 x Fem (max) +55.186 SE 3.36370
Gocha et al. 2013	Tibia and humerus	Male stature = 2.85 x Tib (condylo-malleolar) + 46.8 SE 2.399 Female stature = 3.46 x Hum + 40.1 SE 2.590

Figure 1. Unidentified body recovered from the river in Bangkok. This is an excellent example of cases that require forensic anthropology expertise to identify the deceased.